POSTER SESSION
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A Passive Mitigation Solution to the Effects of Human-Generated Sound on Marine Mammals

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Abstract

Acoustic and physical interactions between human activities and coincident cetacean occurrence have become a threat to marine mammal conservation. Although we do not yet fully understand under what circumstances exposure to loud sounds will cause harm to cetaceans, scientific evidence indicates that such high intensity sounds can cause lesions in acoustic organs, severe enough to be lethal. The use of active acoustic solutions, i.e. acoustic deterrents and active sonar, in areas of interest (shipping, military exercises, gas exploration, etc.) to prevent unfortunate interactions is either range-limited and intrusive or ineffective on cetaceans, specially on those already highly tolerant to noise. An alternative solution based on passive detection, classification and localization has been therefore considered. Here, we introduce a time and cost effective minimal solution applied to sperm whales - but applicable to other cetacean species - to an automatic real-time 3D whale localization. The 3D localization is based on the acoustic signal arrival time-delays and the assumption that sound propagation can be modeled by straight rays, resolving both the azimuth and elevation on a short aperture tetrahedral array of passive sensors and the source distance from the time arrival on a distant fourth hydrophone (wide aperture array). With this configuration, the 3D localization algorithm calculates the whale's position within a 3000m deep and 2500m radius cylinder with an estimated 200m maximum distance error. The system further integrates the tracking of acoustically passive whales by a sperm whale click-based ambient noise imaging sonar. A simulation tool for 3D acoustic propagation was designed to simulate a bi-static solution formed of an arbitrary number of active acoustic sources, an illuminated object, and a receiver all positioned in 3D space with arbitrary bathymetry. Detection and bearing estimates could be performed for silent whales at ranges of 1500m from a 4m diameter array of 32 hydrophones, in a simulated scenario where on-axis click source and ambient noise levels were respectively 200dBrms re 1µPa @1m (full bandwidth) and 60 dBrms re 1µPa in the 1-10kHz band. While an ambitious synthesis of many advanced acoustic technologies, the benefit is an efficient, non-intrusive system which could continuously 3D track cetaceans in areas of interest, therefore mitigating the impact of artificial sound sources on marine mammal populations.

SAKAMATA: A tool to avoid whale strandings

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Abstract

World-wide a concern exists about the influence of man-made noise on marine life, and particularly of high power sonar. Most concern lies with marine mammals that use acoustics for hunting, communication and/or navigation. This concern is fed by recent strandings of whales that could be related to military sonar transmissions and seismic explorations. Especially sonars that use audible frequencies are harmful for these mammals. However, little is known about the exact influence of active sonar on marine mammals and therefore many countries apply the *precautionary principle*. In practice this means that mitigation measures are defined for the use of active sonars. Implementation of such mitigation measures is no sinecure. Background knowledge (presence of mammal species and their hearing sensitivity and behaviour, acoustic conditions) is often lacking. Therefore historical and *in situ* information must be used. TNO-FEL has developed SAKAMATA, a tool that supports the implementation of mitigation measures in an effective way.

Risk Assessment of *ATLAS HYDROSWEEP DS-2 Hydrographic Deep Sea Multi-beam Sweeping Survey Echo Sounder*

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Abstract

The hull-mounted *Atlas Hydrographic* multibeam deep-sea echosounder *Hydrosweep DS-2* is installed on several research vessels (e.g. *R/V Maurice Ewing, R/V Meteor, R/V Polarstern*) to carry out bathymetric surveys of the sea floor. At full ocean depth (3000 to 11000m water depth), the instrument usually operates in "Deep Sea II" mode. In this mode, three short (24, 12 and 24ms) sound pulses of 15.5 kHz are successively emitted, ensonifying a port-, centre- and starboard beam, respectively. This pattern repeats itself at regular intervals of typically 15 seconds. The resulting swath covers an area of approximately twice the local water depth along the profile line.

The sound pressure level (SPL) capable of causing a temporary threshold shift (TTS) is calculated on the basis of experimentally derived TTS threshold levels and the 3-dB exchange rate, resulting in a critical SPL of 203.2 dB_{RMS} rel. 1µPa. For this calculation, a conservatively estimated effective pulse length of 60 ms, i.e. the sum of the three pulses, is used. Then the corresponding region is derived from the *Hydrosweep DS-2* beam pattern. Again a conservative approach selects the maximum SPL of each of the three consecutive pulses for every direction. The resulting critical region is heart-shaped and bounded by a box of 43 m depth, 46 m width athwartship and 1 m (sic!) width fore-and-aft.

Subsequently, regions where reception of multiple pings could lead to a TTS are determined for increasing numbers of assumed ensonifications. Finally the region where potential critical behavioural responses may occur is determined, assuming a sound pressure level commensurate with results from the Bahamas 2001 stranding event.

For cruising ships (*R/V Polarstern* particularly), the study concludes that the risk of causing a TTS to marine mammals is conservatively estimated to be less then 1% of the risk of a collision between the ships-hull and the animal by comparing the relevant volumes and cross-sections. The risk of causing a permanent threshold shift (PTS) will be smaller, though quantification thereof is difficult. For ships on station (zero velocity), the non-zero risk of ensonifying a marine mammal at TTS levels obviously exceeds the risk of collision, as the latter becomes zero. In this later situation, mitigation methods such as a shut down of *Hydrosweep* on station when whales are observed within a certain mitigation radius could serve to eliminate any remaining risks.

Evaluation and Management of the Noise Impact on Marine Mammals in Venezuela – Legal and Technical Aspects

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Abstract

In Venezuela, the legal and regulatory framework includes a series of instruments related to the conservation of natural ecosystems. Accordingly, the Venezuelan State's duties include assuring the conservation and sustainable use of ecosystems and natural resources, as well as to increase both the quality of the human life and of the environment. In a general sense, no specific regulations have been promulgated for the protection of marine mammals. Nevertheless, based on such instruments as the "*National Constitution*", "*Organic Law of Environment*", "*Environment Criminal Act*" and "*Biological Diversity Act*", the Venezuelan State is providing a reference for the protection of the marine habitat and species, including the obligation to prevent, mitigate or correct environmental impacts of economic activities. On the other hand, the Presidential Decree 1257 that deals on *"Guidelines on environmental evaluation of potentially degradative activities*" provides a more specific foundation for evaluating and regulating the impact of sound on cetaceans. Two kinds of activities are considered of special interest for taking into account for conservation and management purposes: 1) Oil and gas exploration/production and 2) Maritime traffic. On the basis of the before-mentioned Decree, since 2002 the MARN authorities have included the evaluation of the effect of sound on cetaceans in the Terms of Reference of Environmental Impact Assessments, Specific Environmental Assessments and Baseline Studies related to the oil industry offshore activities.

Up to the present, the presence of independent observers and MARN officers on board vessels during two seismic surveys reached 1264 hs of effort and yielded 117 cetacean sightings. According to this preliminary results, behavioral changes and/or avoidance reactions have been observed only in mysticetes. Though no research effort is being made currently on the effect of other sources of human-generated sound on these species, specific regulations are being developed jointly by the MARN and non-governmental organizations.

"Gas embolic syndrome" in two single stranded beaked whales

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Abstract

Introduction:
Lesions consistent with in vivo bubble formation in beaked whales have been recently described in **Nature** by Jepson and col. and Fernández and col. A decompression-like syndrome has been postulated to happen in whales in response to sonar exposure. Gas embolism "in vivo" is difficult to determine some time after death. This report presents a systemic "gas bubble" embolism in two fresh single stranded beaked whales.

Material and Methods:
One adult female and one old male beaked whale stranded on the coasts of Gran Canaria and Tenerife in 2003 and 2004 respectively. Both animals were necropsied around 4 to 8 hours after death. A routine necropsy for whales was carried out by pathologists from the Unit of Histology and Pathology (Institute of Animal Health-Veterinary School-University of Las Palmas de Gran Canaria). A routine histological study was also performed in all the sampled organs, as well as a microbiological study.

Results and discussion:
Both animals showed massive gas bubbles in the portomesenteric system, involving changes in the liver. Gas bubbles were seen macroscopically and microscopically in the venous system, including intestines, liver, lymph nodes, lung, kiney, heart and brain. Although a test of nitrogen content of the gas is now underway, the pathological picture is very similar to an acute massive systemic gas embolism in DCS in humans. It is not known if these cases were associated with sonar activities.

Conclusion:
The present results found in two very fresh beaked whales restate and reinforce the "systemic gas embolism" in beaked whales, a new pathologic entity to be described in cetaceans, with special attention to deep, long duration diving species like beaked whales, which seem to be more susceptible of suffering this embolic syndrome.

Jepson and cols. **Nature** 425:575-576(2003).
Fernandez and cols. **Nature** doi:101038/nature 02528 (2004).

New beaked whale mass stranding in Canary Islands associated with naval military exercises (Majestic Eagle 2004)?

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Abstract

Four beaked whales (*Ziphius cavirostris*) stranded in Lanzarote and Fuerteventura (Canary Islands). The first animal stranded the 21st and the last the 28th of July. During the previous week (11th-16th July 2004) an international military naval exercises (Majestic Eagle 2004) took place between the Canary Islands and Morocco. The corpses were autolytic, lacking part of the body in some cases. A necropsy was carried out on 3 out of 4 animals. The last beaked whale that stranded the 28th was not possible to sample. The necropsied animals showed abundant content of aliment in the stomach with, in same cases, large non-digested squids. No macroscopic findings were recorded due to advanced autolysis, but samples from different organs, except the central nervous system, were taken for histology. Samples were processed for routine histological study and also for detecting fat emboli. This report presents epidemiological data and pathological data from this new beaked whale mass stranding associated with naval exercises.

Pathological study of a mass stranding of beaked whales associated with military naval exercises (Canary Islands, 2002)

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Abstract

A study of the lesions of beaked whales in a recent mass stranding in the Canary Islands following naval military exercises provides evidence of the possible relationship between anthropogenic, acoustic (sonar) activities and the stranding and death of marine mammals. Fourteen beaked whales were stranded in the Canary Islands close to the site of an international naval exercise (Neo-Tapon 2002) held on 24 September 2002. Strandings began about 4 hours after the onset of the use of mid-frequency sonar activity. Eight Cuvier's beaked whales (*Ziphius cavirostris*), one Blainville's beaked whale (*Mesoplodon densirostris*) and one Gervais' beaked whale (*M. europaeus*) were necropsied and studied histopathologically. No inflammatory or neoplastic processes were noted, and no pathogens were identified. Macroscopically, whales had severe, diffuse congestion and hemorrhage especially around the acoustic jaw fat, ears, brain, and kidneys. Gas bubble-associated lesions and fat embolism were observed in vessels and parenchyma of vital organs. This *in vivo* bubble formation associated with sonar exposure may have resulted in modified diving behavior that caused nitrogen super-saturation in excess of a threshold value normally tolerated by the tissues (as occurs in decompression sickness). Alternatively, a physical effect of sonar on *in vivo* bubble precursors (gas nuclei), the activation level of which may be lessened by nitrogen gas super-saturation of the tissues, may explain the phenomenon. Both mechanisms might also work together to augment and maintain bubble growth. Exclusively or in combination, these mechanisms might initiate the embolic process. Severely injured whales died, were killed by predators, or became stranded and died due to a more severe cardiovascular collapse during beaching. The present study demonstrates a new pathologic entity in cetaceans. This syndrome that is apparently fostered by exposure to mid-frequency sonar particularly affects deep, long duration, repetitive diving species like beaked whales.

Further Analysis of 2002 Abrolhos Bank, Brazil Humpback Whale Strandings Coincident with Seismic Surveys

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Abstract

A paper, "Are seismic surveys responsible for cetacean strandings? An unusual mortality of adult humpback whales in Abrolhos Bank, northeastern coast of Brazil" (Engel et al. 2004), was presented to the 2004 International Whaling Commission Scientific Committee. It presented strandings data for the northeastern coast of Brazil, the areas where seismic surveys were conducted in 2002, and an overview of the IBAMA efforts to establish guidelines for the seismic activities in the Brazilian coast. While the paper concluded that a scientific correlation between increased adult humpback strandings and seismic surveys along the east coast of Brazil can not be established, the authors nevertheless suggest that seismic surveys be suspended offshore from the Abrolhos Bank region (Bahia and Espírito Santo States) during the humpback whale breeding season from July to November.

The geophysical industry has compiled data on all seismic surveys conducted off the Brazilian coast from 1999 to 2003. It has further conducted an independent analysis of this seismic activity over a 5 year period around the 2002 season as well as the location of the 8 adult humpback whale mortalities noted in Engel et al. 2004 relative to coincident seismic activity. In this poster session the geophysical industry will present details of these data and analyses and will examine the major premises of Engel et al. 2004 against them. It will offer an examination of the scientific literature quoted in Engel et al. 2004 in support of its conclusions as well as how this literature was used, and will draw conclusions about what lessons the 2002 humpback mortalities should offer managers considering mitigations of seismic activity.

Underwater Noise Pollution: Impacts on Marine Life & Recommendations for International Regulatory Action

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Abstract

Anthropogenic noise is a form of pollution that poses significant threats to marine mammals, fish and other ocean wildlife including displacement, injury and mortality. The use of technologies that produce intense underwater noise pollution may be in breach of Article 194(1) of the UN Convention on the Law of the Sea which requires States to take all measures necessary to prevent, reduce and control pollution of the marine environment and Articles 204-206 which require States to assess potentially negative impacts on the environment.

Acoustic energy is not restricted by national boundaries and there is growing consensus that undersea noise pollution should be regulated by responsible international institutions The Scientific Committee of the International Whaling Commission in July 2004 issued a strong statement of concern about intense underwater noise stating that there is compelling evidence that marine mammal populations worldwide are potentially threatened especially by intense military sonars and air guns used in geophysical research and oil and gas exploration. They asked that noise exposure standards be included in national and international ocean conservation plans.

The Scientific Committee to ACCOBAMS issued a formal recommendation on "Man-Made Noise" urging extreme caution in using intense acoustic devices and the 2003 meeting of ASCOBANS passed a resolution affirming their commitment to apply the Precautionary Principle to ocean noise.

NATO representatives met with MEP's, scientists and NGO's in October, 2003 to receive petitions signed by 70 environmental groups in Europe and North America, representing memberships of 8.3 million people, and consider requests for regulatory action on underwater noise pollution. NGO's gave a presentation on Intense Underwater Noise Pollution at the Fifth UN Informal Consultative Process on Oceans and the Law of the Sea in June, 2004 discussing science, legal aspects and political activities urging international regulation of ocean noise. NGO's worldwide are forming an International Coalition for Ocean Noise Management.

The Behavioural Responses of Dugongs to Two Noise Sources: Boats and Pingers

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Abstract

The objectives of this project were to determine the risk disturbance from boats and pingers (acoustic alarms) through direct observations of dugong (*Dugong dugon*) behaviour. To observe dugongs I developed the blimp-cam; this consists of a helium-filled balloon (blimp) with a mounted video camera. I assessed the behavioural responses of dugongs to opportunistic and experimental boat passes in Moreton Bay, Australia. The feeding and travelling behaviour during 4.5 min focal follows was not affected by the experimental boat passing, the number of passes made, whether the pass was continuous or included a stop and restart, or the individual's position in the herd in relation to these three factors. However, individual dugongs were significantly less likely to remain feeding if a boat passed within 50 m. Feeding herds often responded to boats by performing mass movements, which on average lasted 2 min. During the time of year my study was conducted, boat traffic may disturb dugongs for 0.8 to 6 % of the time they spend feeding. This level of disturbance presents minimal risk of displacing dugongs from my study site where seagrass beds are large enough for dugongs to move and recommence feeding immediately. The response to an array of two 10 kHz pingers (acoustic alarms designed to reduce entanglement in fishing nets) was also observed. Pinger noise did not significantly affect the rate of dugong movement away from the focal arena surrounding the pingers, the orientation of these dugongs, or the presence or absence of feeding plumes. The results from these pinger experiments suggest dugongs are unlikely to be displaced from important habitat areas by pingers.

The influence of acoustic emissions for underwater data transmission on the displacement of harbor porpoises (*Phocoena phocoena*) in a floating pen and harbor seals in a pool

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Abstract

To prevent grounding of ships and collisions between ships in shallow coastal waters, an underwater data collection and communication network is currently under development: Acoustic Communication network for Monitoring of underwater Environment in coastal areas (ACME). Marine mammals might be affected by ACME sounds since they use sounds of similar frequencies (around 12 kHz) for communication, orientation, and prey location. If marine mammals tend to avoid the vicinity of the transmitters, they may be kept away from ecologically important areas by ACME sounds. The most abundant marine mammal species that may be affected in the North Sea are the harbor porpoise and the harbor seal. Therefore, as part of an environmental impact assessment program, two captive harbour porpoises and nine harbour seals were subjected to four sounds, three of which may be used in the underwater acoustic data communication network. The effect of each sound was judged by comparing the animals' positions and respiration rates during test periods with those during baseline periods. Each of the four sounds could be made deterrent by increasing the amplitude of the sound. Both the porpoises and the seals reacted by swimming away from the sound source. The porpoises increasing their respiration rate slightly, but the seals' respiration rate remained the same. From the sound pressure level distribution in the enclosures, and the distribution of the animals during test sessions, discomfort sound pressure level threshold were determined for each sound. The acoustic discomfort threshold is defined as the boundary SPL between the areas that the animals generally occupied during the transmission of the sounds and areas that they generally did not enter during transmission. In combination with information on sound propagation in the areas where the communication system may be deployed, the extent of the 'discomfort zone' can be estimated for several source levels. The discomfort zone is defined as the area around a sound source that animals are expected to avoid. Based on these results, source levels can be selected that have an acceptable effect on harbor porpoises and harbor seals in particular areas. The source level of the communication system should be adapted to each area (taking into account bounding conditions created by narrow channels, sound propagation variability due to environmental factors, and the importance of an area to the affected species). The discomfort zone should not prevent porpoises and seals from spending sufficient time in ecologically important areas (for instance resting, breeding, suckling, and feeding areas), or routes towards these areas.

Snapshot of MMS Research on Cetaceans and Anthropogenic Presence

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Abstract

Initially, the Environmental Studies Program (ESP) addressed broad, general information needed to assess OCS activity compliance with the National Environmental Policy Act; that is, baseline studies or surveys. However, more specific information needs pertaining to those species given protection under the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA) began to develop. In the early ESP years, many baseline studies/surveys of protected and endangered species were conducted to develop an understanding of populations, abundance and distributions, and preferred areas for feeding, breeding and birthing. These studies helped address issues pertaining to space conflict and multiple use. Concurrent with this baseline work, research needs associated with the "potential" effects of oil and gas and marine minerals activities began to evolve. These later concerns surrounded potential impacts from sources other than oil spills and drilling discharges, such as noise and disturbance. By the mid-1980's, studies on the effects of noise on marine mammals were initiated in our Alaska and Pacific OCS Regions. In 1987, MMS sponsored a comprehensive literature review of the effects of noise, particularly focusing on the oil and gas industries. In 1992, the Office of Naval Research (ONR) provided core funding to convert this MMS report into an expanded publication: "Marine Mammals and Noise" published by Academic Press (1995).

Featured in the poster are two MMS studies which address the issues of anthropogenic presence, noise and endangered whales. The "Bowhead Whale Aerial Survey Project" is a 20 plus year effort to understand the bowhead migration and potential impacts from anthropogenic presence. The other featured study is the "Sperm Whale Seismic Survey" a multi-phased effort to get snapshot and broad views of the presence and use by sperm whales of the deep waters of the Gulf of Mexico - areas of exploratory oil and gas activities.

Active sonar and the marine environment

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Abstract

A study of the effects of active sonar transmissions on fish and marine mammals in Norwegian waters has been launched, following ordering of new frigates by the Royal Norwegian Navy (RNoN). The objective of the study is to produce a set of recommended rules for naval sonar operations in Norwegian waters based on scientific grounds. The project includes studies of physiological and behavioral effects of sonar signals on fish and marine mammals, as well as development of a decision aid system to assure responsible operation of naval sonars within Norwegian waters.

Undersea Noise Pollution – A Challenge for Science, Governments and the Civil Society

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Abstract

A growing body of evidence indicates that undersea-noise pollution can have various adverse impacts on marine life and thus constitutes a severe threat to the marine organisms and ecosystems. The intense and widespread undersea noise is an issue of increasing importance and has already been addressed by several international institutions (including IWC, IMO, ASCOBANS and ACCOBAMS).

In 2002 ASMS OceanCare founded the European Coalition for Silent Oceans and commissioned a legal analysis on the use of low frequency active sonar (LFAS) by Dr. Alexander von Ziegler, a Swiss expert in sea law. In his expert report entitled "The use of LFA Sonar under International Law" A. von Ziegler concluded that the use of LFAS violates four of the most important general principles of customary law (sovereignty over natural resources and the responsibility not to cause damage to the environment of other states or of areas beyond the limits of national jurisdiction, principle of preventive action, principle of sustainable development, precautionary principle) as well as the obligations deriving from several international conventions. In 2003 the expert report has been distributed to the relevant conventions and to the ministers of defense, foreign affairs and environment of all NATO and UN states. Reactions from numerous ministers showed concern.

Various petitions against the use of military sonar systems have been handed over to the European Parliament and to NATO. The fatal effects of sonar technology have been discussed with the NATO representatives, who since are looking into alternative methods and have intensified efforts to protect marine mammals from the hazardous effects associated with sonar tests. At the 5th UN conference on "Oceans and the Law of the Sea" an NGO delegation presented an overview of the scientific aspects, the legal arguments, and the political activities aiming at placing Ocean Noise under intergovernmental regulation.

ABR responses in two species of marine mammals

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Abstract

Plans exist to built numerous offshore windfarms in the North and Baltic Sea, comprising several thousand windmills. The sound emitted during the construction (225+dB re 1µPa) as well as the operation of the windmills is considered to have potentially negative impact on marine mammals. Therefore an audiometric study on harbour porpoises and harbour seals has been initiated within the framework of the research projects MINOS. This study comprises measurements of the absolute hearing threshold of both species in captivity as well as of harbour seals in the wild. These data are prerequisite as a baseline for a subsequent resilience test (TTS test) of the animal's auditory system. The measurement of auditory brainstem response (ABR) is being used in this study. This method is a common tool to investigate the auditory abilities of vertebrates including humans. So far measurements have been conducted on a wild and a captive harbour seal with wideband signals at 4kHz, a male harbour seal with narrow band tone bursts of 0.125 to 16kHz, a male harbour porpoise with tone bursts of 0.3 to 2kHz and amplitude-modulated sounds of 2kHz to 22.4kHz. Thresholds were determined using a correlation technique as well as regression analysis. The resulting audiograms are in accordance with the shape of behavioural audiograms, although thresholds are shifted to higher values. Further animals are currently measured for their absolute hearing threshold and TTS measurements are in preparation. In addition, the responses of seals to broad-band click stimuli was measured comparatively on the captive and on wild animals. ABR waveforms and hearing thresholds were similar to those of the captive individual. It can be concluded that ABR measurements can become a tool for an ecological survey programme with wild-caught animals if more experience is gathered regarding the precise assessment of auditory thresholds under suboptimal conditions.

Multi-scale impact assessments can help detect impact, infer its mechanism and consequences and provide tools for management

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Abstract

Boat traffic, and particularly the traffic associated with the tourism industry, generates a significant proportion of the noise to which cetaceans are exposed because of the overlap between coastal cetacean habitat and this activity. Interactions with vessels are chronic intermittent stressors for cetaceans, but the long-term consequences of these impacts are often difficult to detect due to methodological issues. We report on the framework of a study conducted in Doubtful Sound, New Zealand which assessed the effects of boat interactions on bottlenose dolphins (*Tursiops* spp.). We tested whether the presence of boats, their type, and their behaviour, affected the diving pattern of individuals, the behavioural events observed in groups of dolphins as well as the behavioural state of these groups. We therefore looked for various short-term reactions at the individual and group levels. Combining the effects observed at these two ecological levels allowed us to infer both the mechanisms by which vessel interactions were impacting the dolphins and the long-term biological cost of these interactions for individuals and the population. We found that dolphins were more sensitive to boat presence when they were resting or socialising. We also showed that boats misbehaving increased the effect size of the impact, especially for females. We proposed a multi-level reserve to mitigate these effects based on the dolphins' spatial behavioural ecology. Adapting the management of boat interactions to reduce exposure, either spatially or temporally, during sensitive behavioural states is likely to be an efficient mitigation tool. We think that this framework could be readily applied to other situations where the detection and mitigation of anthropogenic impacts on animals is required.

Passive Acoustic Marine Mammal Monitoring Technology for Navy Ranges

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Abstract

The Office of Naval Research (ONR) program, Marine Mammal Monitoring on Navy Ranges (M3R), has leveraged the infrastructure of U.S. Navy undersea ranges to develop a set of tools for passive detection and localization of marine mammal calls. Widely-spaced, bottom mounted omni-directional hydrophones are used to monitor animal calls over broad spatial and temporal scales. The tools are designed for use with diverse calls including clicks, sweeps, and whistles. Call frequency can vary from 50 Hz to 50 kHz. Calls are detected, precisely time-tagged using a GPS reference, and detection reports generated. Calls are divided in to 2 broad classes, clicks and "everything else." The Time Difference of Arrivals (TDOA) between a master hydrophone and those surrounding are calculated. For clicks, this is done directly using a data association algorithm. For all other calls, a 2-D spectrogram cross correlation is first performed. A hyperbolic tracking algorithm is then used to localize the calls. 3-D tracks are obtained for repetitively vocalizing animals. Included in the tool set are real-time displays that allow simultaneous monitoring of all range hydrophones. For installations such as the Atlantic Undersea Test and Evaluation Center (AUTEC), up to 82 hydrophones covering an area of over 500 square nautical miles are utilized. Displays for receiver detection statistics, individual receiver output spectrograms, and X-Y geo tracking displays are provided. The current detection algorithm runs on a massively parallel Digital Signal Processor (DSP). A replacement processor based on commodity Linux cluster technology is under design. This processor will reduce the cost of hardware by up to a factor of 10, making the tools affordable for a diverse set of applications.

Noise Pollution Case Study: Cetaceans in Hong Kong

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Abstract

Hong Kong has two resident species of cetacean: the Indo-Pacific humpback dolphin and finless porpoise. However, Hong Kong is one of the busiest ports in the world, with approximately half a million oceanic and river-going vessels travelling through its waters every year, including over 10,000 transits by high speed ferries through the area of greatest humpback dolphin abundance. This shipping traffic will eventually increase, as new regular shipping routes to Hong Kong from mainland China have been proposed. Studies have demonstrated changes in dolphin behaviour in response to boat traffic, including avoidance of fast vessels.

In 1995 a sanctuary was established by the Hong Kong government around the islands of Sha Chau and Lung Kwu Chau, an area important for resident humpback dolphins. However, over 200 vessels can surround this sanctuary area at any time, and the Urmston Road shipping channel is located immediately to the north of the sanctuary. The sanctuary itself was a measure to mitigate, and compensate, for the construction of a temporary aviation fuel receiving facility off Sha Chau, the construction of which incorporated pile driving and additional boat traffic. A bubble curtain was used to try to mitigate the noise produced by the pile driving.

Adjacent to the sanctuary in the south is Chek Lap Kok airport, which when at full capacity will have over 700 planes descending and taking off daily, directly over the sanctuary and other critical dolphin habitat. The airport itself is constructed from an island which was an area frequently used by dolphins, prior to the infilling of the surrounding waters and the demolition of the island itself in 1993 to produce the airport platform; all activities involving high noise input into cetacean habitat.

In addition, there are increasing numbers of dolphin-watching vessels specifically targeting areas of high dolphin abundance. A recent land-based study demonstrated that longer dolphin dive times, and shorter periods at the surface, were recorded when dolphin-watching boats were present. Recently, small motorized boats have also been reported chasing dolphins at high speed to the south of the sanctuary area.

Cetaceans in Hong Kong are exposed to high levels of anthropogenic contaminants, their food supply is depleted, and there is evidence of some anthropogenic mortality and injury through fisheries by-catch and ship-strikes. Noise is adding another, potentially major, anthropogenic stressor to already impacted populations.

Tools for Underwater Noise Monitoring, Marine Mammals' Surveys, and Implementation of Acoustic Risk Mitigation Policies

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Abstract

The concern that man-made acoustic signals can affect marine mammals has increased over the past few years, mainly within the context of low-frequency active sonars and seismic surveys. Whether it is in support of acoustic risk mitigation measures, or in the larger context of environmental monitoring, recent years have seen an increasing use of underwater passive acoustics.

Passive acoustics is a powerful tool to be used for (a) expanding knowledge about marine mammals' behaviour, ecology and distribution; (b) monitoring underwater noise; (d) monitoring critical habitats; (e) evaluating the effects of sound exposure on animals' behaviour; (f) implementing mitigation policies by detecting animals within or approaching a possibly dangerous sound exposure area.

To support the Acoustic Risk Mitigation Policies being developed by many national and international civil and military organizations a PC based Sound Analysis Workstation was designed and extensively tested to provide an affordable and flexible tool for wide band acoustic detection and monitoring. It provides detection, processing, storage and plotting capabilities and can be used for both wide area surveys and local monitoring needs.
In many years of extensive use it has been demonstrated the importance of broadband detection, continuous 24/24h monitoring and integration of visual cues to maximize detection capabilities.

The package includes software for 1) recording and analyzing sounds received by up to 8 wide band sensors, 2) manage a sonobuoys' radio receiver, 3) recording and distributing NMEA navigation data, 4) logging and classification of acoustic contacts, 5) logging visual contacts, 6) sharing data among a network of PCs, 7) plot georeferenced data on a GIS.

The research has been carried out within the NATO Saclantcent's SOLMAR Project with ONR Grants N00014-99-1-0709, N00014-02-1-0333, and N00014-03-1-0901.

Environmental Stewardship: Maritime Forces Atlantic's Marine Mammal Impact Mitigation

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Abstract

The Canadian Department of National Defence has a policy of environmental stewardship. In being mindful of the potential impact related to its operations, Maritime Forces Atlantic has undertaken an Environmental Assessment of its training activities in the Atlantic Operating Areas, created the framework of an Environmental Management System, created computer-based environmental risk assessment tools, and has drafted a "Standard Operating Procedure" on the observation of marine mammals and reptiles. This poster will present a brief overview of the effort.

Marine mammal monitoring and mitigation during recent seismic surveys for geophysical research

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Abstract

The R/V *Maurice Ewing*, operated by Lamont-Doherty Earth Observatory of Columbia University, conducts academic marine seismic surveys sponsored by the U.S. National Science Foundation. In autumn 2002, a beaked whale stranding occurred in Baja California when the *Ewing* was operating its largest airgun configuration (20 guns; 8600 in^3) nearby. No causal link was confirmed. However, subsequent *Ewing* seismic surveys have included progressively more stringent monitoring and mitigation measures under provisions of Incidental Harassment Authorizations issued by the U.S. National Marine Fisheries Service (NMFS). ***Monitoring*** includes visual observations by trained marine mammal observers during all daytime airgun operations and during nighttime ramp-ups, when allowed. Starting in 2004, a towed hydrophone array is monitored day and night for cetacean calls when the larger airgun configurations are used. ***Pre-cruise mitigation*** includes selecting the smallest airgun array consistent with the geophysics objectives and, where possible, adjusting plans to avoid seasons and/or locations of special concern for marine mammals, sea turtles, and most recently fisheries. ***Mitigation during cruises*** includes ramp-ups, plus power-downs (to one small airgun) or shut-downs when mammals and (recently) sea turtles are detected within a "safety radius": the 180 dB re 1 μPa (rms) distance for cetaceans and sea turtles, and the 190 dB radius for pinnipeds. Specific rules determine when airgun operations can resume after a shut-down or power-down. ***Acoustic measurements*** showed that the safety radii are greater in shallow than deep water. Recently, depth-dependent safety radii have been applied, and other mitigation measures have been more stringent in shallow waters. ***Conclusions:*** No one monitoring or mitigation measure is entirely effective in detecting marine mammals or avoiding their exposure to strong airgun sounds. However, different monitoring and mitigation techniques can be complementary. In judiciously-chosen combinations, they can substantially reduce the likelihood of biologically-significant effects. These benefits have costs to the seismic operator.

Canadian Environmental Legislation Impacting to Sonar R&D

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Abstract

Defence Research and Development Canada (DRDC) Atlantic has a number of projects which require the transmission of acoustic energy. Because of potential adverse environmental affects, a number of Canadian laws and Department of National Defence (DND) policies impact on these research activities. In particular the Fisheries Act, the Oceans Act, the Canadian Environmental Assessment Act (CEAA), the Canadian Environmental Protection Act (CEPA), and the Species at Risk Act (SARA) influence the operation of research trials. Under CEAA research activities on CFAV Quest within Canadian waters are exempt from the requirement to carry out an environmental impact assessment; however, DND policy requires that the assessment be carried out. This poster provides an overview of the relevant legislation and policies together with a description of DRDC Atlantic's approach to addressing the various concerns in its EA process.

Effects from pile driving operations on harbour porpoises at Horns Reef offshore wind farm, monitored by T-PODs and behavioural observations

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Abstract

The world's largest offshore wind farm was build on Horns Reef in the Danish North Sea in 2002. It consists of 80 2 MW wind turbines, mounted on steel monopile foundations. The monopiles were driven into the seabed with a hydraulic hammer, a procedure generating high underwater noise levels (not quantified). Underwater acoustic alarms (AQUAmark pingers and seal scrammer) were deployed prior to each pile driving operation in order to deter marine mammals from the vicinity of the operation and hence protect them from excessive sound exposure.

Reactions of harbour porpoises was monitored by visual surveys from ship and by acoustic dataloggers (T-PODs), both inside and outside of the wind farm.

Average time from end of each pile driving operation to the first porpoise encounter recorded by the T-PODs increased significantly from the average time between encounters in periods without pile driving (from 50 minutes to close to 300 minutes). Average interval between first and second encounter after end of pile driving was not significantly larger than outside pile driving periods, indicating return to levels normal for the construction period as a whole. Observations from ship surveys showed a significant change in surface behaviour on days with pile driving at distances up to 10 nautical miles from the wind farm. The most frequent behaviour changed from non-directional movement (presumably associated with feeding) to directional movement on days with pile driving operations.

Both data sets points to a strong and immediate effect of the pile driving operations (caused by AQUAmark pingers and seal scrammers and impact sounds from the hydraulic hammer), followed by a rapid recovery to the situation normal for the construction period. This normal situation was not undisturbed, as other, less noisy activities took place during the entire period, as well as a general high level of ship traffic during construction.
A separate, ongoing study will address permanent effects from the construction and operation of the wind farm.

The study was supported financially by the Danish National Energy Authority.

Whales and the WAXA: Defence Sponsored Whale Research off the West Coast of Australia

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Abstract

The Western Australia Exercise Area (WAXA), situated near Perth, Western Australia, is one of the primary maritime exercise areas of the Australian Defence Force (ADF). The waters of the WAXA are used extensively by ships, submarines and aircraft of the ADF, and shared with merchant shipping, commercial fishing and recreational activities such as whale watching.

Parts of the WAXA are also an important migration route for the humpback whale (*Megaptera novaeangliae*) and an aggregation area for the blue whale (*Balaenoptera musculus*). In recognition of the periodic presence of these threatened species in the WAXA, the Australian Department of Defence has sponsored and coordinated an extensive research program into the status and habits of blue whales in the WAXA. This research has been conducted in collaboration with leading researchers and government regulatory authorities.

In a wider context, Defence has also undertaken an exhaustive review of all activities carried out at sea and the way in which these activities may have an impact upon all aspects of the environment, including marine mammals. Coupled with the specific knowledge gained from the WAXA blue whale research program, Defence has developed a range of standard environmental risk mitigation measures which are employed by all ADF units operating at sea.

This poster will:

- Describe relevant geographical and biophysical features of the WAXA, including the status of marine mammals and blue and humpback whales in particular.
- Describe Defence activities in the WAXA, including history of use.
- Outline the planning and conduct of ADF activities to minimise risks to marine mammals.
- Describe Defence-sponsored whale research in the WAXA.
- Describe liaison and consultation undertaken by Defence with regulatory authorities, researchers and other stakeholders regarding protection of marine mammals.

Regulatory Authority of the States over acoustic activity, with emphasis on California

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Abstract

In the United States the Federal Coastal Zone Management Act (CZMA) designates management authority to States over federal waters off shore of the States, once a state's coastal management program is certified by the federal government. The CZMA gives state coastal management agencies regulatory control (federal consistency review authority) over all federal activities and federally licensed, permitted or funded activities affecting the coastal zone (regardless of whether they occur within, landward or seaward of the coastal zone boundary), if the activity affects the land or water uses or natural resources of the coastal zone. In California the California Coastal Commission (CCC) is the designated coastal management agency. The regulations and the regulatory processes in California under the federal CZMA and under State law (the California Coastal Act) will be discussed with respect to underwater acoustic activities. Policy evolution over the past two decades will also be examined, as well as comparisons and contrasts with procedural and policy positions taken by other states.

In addition, the discussion will include examples of migitation requirements imposed by the States on activities that produce sound, including seismic surveys for oil and gas, geologic investigations and other research, pier and platform decomissioning, Naval activities. etc.

A Regulatory Agency Perspective on Anthropogenic Noise and Marine Mammals

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Abstract

MMS administers about 7,500 active leases on 40 million acres of the Outer Continental Shelf (OCS). The OCS makes a significant contribution to the national energy supply, providing 25 percent of the natural gas and 30 percent of the oil produced in the United States. The MMS carries out its mission of managing OCS mineral resources through a variety of efforts: estimating national OCS energy resources; assessing environmental impacts; funding research to assess and manage impacts of activities and to monitor changes in the quality and productivity of the marine environment; leasing OCS acreage; analyzing and permitting proposed actions; inspecting operations; enforcing statutory and regulatory requirements; and providing scientific and technical assistance to other nations.

The MMS protected species program involves complying with the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA); analyzing impacts; designing mitigation, monitoring guidelines and management approaches; and providing information necessary for promulgating regulations; and identifying, funding, and participating in research necessary for the protection and enhancement of protected species and their habitat.

MMS has focused two programmatic environmental analyses (under the National Environmental Policy Act [NEPA]) on noise producing activities (seismic surveys and explosive removals of offshore structures). The programmatic environmental assessments characterize activities and the environment in which they occur, document potential environmental impacts and mitigation measures, and evaluate proposals.

To avoid or reduce the potential impacts of noise MMS, implements mitigation measures (based on NEPA analyses, ESA consultations, and MMPA collaboration) through a variety of mechanisms including regulations (30 CFR Part 250 - Oil and Gas and Sulphur Operations in the Outer Continental Shelf) that implement provisions of the OCS Lands Act (U.S. Code Title 43, Chapter 29, Subchapter III), lease stipulations, and notices to lessees (which clarify requirements addressed in our regulations).